(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 646 125 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
27.05.1998 Bulletin 1998/22

(21) Application number: **93912478.0**

(22) Date of filing: **18.06.1993**

(51) Int Cl.[6]: **C07H 19/04**, C07D 473/04, C07D 405/04, A61K 31/70

(86) International application number:
PCT/BE93/00036

(87) International publication number:
WO 93/25565 (23.12.1993 Gazette 1993/30)

(54) 1,5-ANHYDROHEXITOL NUCLEOSIDE ANALOGUES AND PHARMACEUTICAL USE THEREOF

1,5-ANHYDROHEXITOLNUKLEOSIDANALOGE UND PHARMAZEUTISCHE VERWENDUNG DAVON

ANALOGUES DE NUCLEOSIDES A BASE DE 1,5-ANHYDROHEXITOL ET LEUR UTILISATION PHARMACEUTIQUE

(84) Designated Contracting States:
AT BE CH DE DK ES FR GB GR IE IT LI LU MC NL PT SE

(30) Priority: **18.06.1992 EP 92201803**

(43) Date of publication of application:
05.04.1995 Bulletin 1995/14

(73) Proprietor: **Stichting REGA V.Z.W.**
3000 Leuven (BE)

(72) Inventors:
- **DE CLERCQ, Erik, Désiré, Alice**
  B-3360 Lovenjoel (BE)
- **HERDEWIJN, Piet, André, Maurits**
  B-3111 Rotselaar (Wezemaal) (BE)
- **VAN AERSCHOT, Arthur, Albert, Edgard**
  B-2220 Heist o/d Berg (BE)

(74) Representative:
Van Someren, Petronella F. H. M. et al
Arnold & Siedsma,
Advocaten en Octrooigemachtigden,
Sweelinckplein 1
2517 GK Den Haag (NL)

(56) References cited:
EP-A- 0 217 580 **EP-A- 0 409 227**
WO-A-90/01036

- **JOURNAL OF MEDICINAL CHEMISTRY vol. 30, no. 6, June 1987, WASHINGTON US pages 1044 - 1054 L.D.NORD ET AL. 'Synthesis, Structure, and Biological Activity of Certain 2-Deoxy-B-D-ribo-hexopyranosyl Nucleosides and Nucleotides.' cited in the application**
- **JUSTUS LIEBIGS ANNALEN DER CHEMIE vol. 1990, no. 11, November 1990, WEINHEIM DE pages 1079 - 1082 P.HANSEN ET AL. 'Synthesis of 3'-Azido-2', 3'-Dideoxy-B-D-arabino-hexopyranosyl Nucleosides.' cited in the application**

EP 0 646 125 B1

Description

Technical field

This invention relates to nucleoside analogues with an aglycone six-membered ring which exhibits remarkable antiviral activities. This invention further relates to the chemical synthesis and the pharmaceutical and/or medical use of such nucleoside analogues.

Background

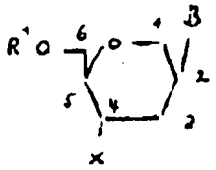
Pentofuranosyl nucleosides are nucleosides in which a pentofuranose ring, that is, a heterocyclic five-membered ring, which is derived from pentose sugars, is bonded to the heterocyclic ring of a pyrimidine or purine base. Substituents can be present on each of both rings. Ring atoms as well as pendant hydroxy and amino groups can be replaced by other atoms or groups whereby a large number of possible variations is created.

Different pentofuranosyl nucleosides are known for their anti-viral activities. Nucleosides for example with a 2-deoxy-2-fluor-D-arabinofuranose moiety have a potential anti-viral activity against herpes viruses and are among the most active anti-herpes agents. Compare De Clercq et al., Biochem. Pharmacol. 33, 2159 (1984). A number of these nucleosides has already been tested in vivo. Their antiviral activity is dependent on the presence of a virus-specific thymidine kinase, whereby they are converted into the corresponding 5'-monophosphate derivatives. The monophosphates are further phosphorylized by cellular enzymes to triphosphates which then inhibit the viral DNA polymerase.

In the same manner base modifications of the natural 2'-deoxy nucleosides can provide these nucleotides with an anti-viral activity against herpes viruses. This activity of for instance 5-iodo-2'-deoxyuridine and E-5-(2-bromovinyl)-2'-deoxyuridine is likewise dependent on a virus-specific thymidine kinase. Compare De Clercq et al., in Developments in Anti-viral Chemotherapy, pages 21-42 (1980), Ed. Collier and Oxford, Acad. Press.

Description of the invention

The present invention relates to 1,5-anhydrohexitol nucleoside analogues, wherein a 4-substituted-2,3,4-tri-deoxy-1,5-anhydrohexitol is coupled via its 2-position to the heterocyclic ring of a pyrimidine or purine base. They are represented by the formula I:

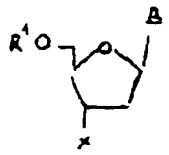


(I)

wherein B is a heterocyclic ring which is derived from a pyrimidine or purine base, and
wherein X represents a hydrogen atom, azido, F, Cl, Br, I, amino, $-NHR^2$, $-N(R^2)_2$, $-OR^2$, $-SR^2$ or CN,
wherein R^1 and R^2 are the same or different and represent hydrogen, alkyl, acyl or phosphate groups; wherein alkyl is a straight or branched chain, saturated or unsaturated, substituted or non-substituted hydrocarbon radical with 1-20 carbon atoms; and acyl is an alkanoyl or aroyl group, wherein alkanoyl is an alkylcarbonyl radical and wherein alkyl is as described above and aroyl is a benzoyl, substituted benzoyl or naphtoyl;
or wherein X is hydrogen and a double bond is situated between the 3- and 4- position of the 1,5-anhydrohexitol ring.

Pharmaceutically acceptable salts and esters of the compound of formula I are included in the invention.

The nucleoside analogues of formula I are new compounds. They display a certain similarity with 2'-deoxypentofuranosyl nucleosides of formula II wherein B, R^1 and X have the same designation as in formula I, except for the enlargement of the ring with a methylene group between the ring oxide and the carbon which is coupled to the base.



(II)

According to the invention it has been found that the nucleoside analogues of formula I and their salts and esters exhibit remarkable anti-viral properties against herpes viruses, pox viruses and related viruses. Different analogues are selectively inhibiting for Herpes simplex virus type 1, Herpes simplex virus type 2, Varicella zoster virus and Cytomegalo virus. A new class of anti-herpes agents has therefore bean found.

A number of nucleoside analogues has already been described by ourselves and others, which analogues contain a pyranose group (as well as pentoses and hexoses), but not a single one has been described as possessing anti-viral activities. Compare Herdewijn et al., Nucleosides, Nucleotides 10, 119-127 (1991) (pentoses, 2-deoxy-2-fluoro-pentopyranoses, inactive); Herdewijn et al., Bull. Soc. Chim. Belg. 99 895-901 (1990) (hexoses, inactive); Kaluza et al., Acta Chem. Scand. 44 294-296 (1990) and Hansen et al., Liebigs Ann. Chem. 1079-1082 (1990) (3-azidopyranoid analogues of AZT, inactive); Nord et al., J. Med. Chem. 30, 1044-1054 (1987) (2-deoxy-hexopyranoses, from inactive to very low activity). Until now it has not been found of a single hexose nucleoside that it is a substrate for cellular or viral kinases and thereby has an anti-viral effect. Insertion of an additional oxygen or nitrogen in the pentofuranose group, whereby analogues were created with a dioxane or morpholine moiety, equally did not provide the obtained compounds with any desired anti-viral properties. Compare Van Aerschot et al., Bull. Soc. Chim. Belg. 99 769-777 (1990).

The fact that anti-viral activities are found among the nucleoside analogues of formula I must be deemed surprising despite their configurational analogy with nucleosides of formula II. The effect of enlarging the pentofuranosyl ring to a 1,5-anhydrohexitol ring could not be anticipated beforehand. This is illustrated by the absence of anti-viral properties in the above mentioned derivatives.

The invention also relates to pharmaceutical compositions from the nucleoside analogues of formula I and, where possible, to the use of these nucleoside analogues in therapy, for instance in the treatment or prophylaxis of virus infections, in particular herpes virus infections, for example herpes simplex virus types 1 and 2, Cytomegalo virus and Varicella Zoster virus, or against pox viruses, for instance vaccinia virus (VV).

More detailed description of the invention

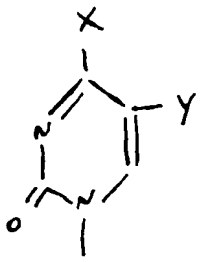
Compounds

The invention will now be described in more detail. The compounds according to the invention are nucleoside analogues wherein a 4-substituted-2,3,4-trideoxy-1,5-anhydrohexitol is coupled via its 2-position to the heterocyclic ring of a pyrimidine or purine base. They can be represented by the above stated formula I, wherein B, R^1 and X have the above stated designations. Pharmaceutically acceptable salts and esters are likewise included.

The hexitol has the (D)-configuration and the base and the X substituent have the (S)-configuration. Preferably X represents hydroxyl in the (S)-configuration.

Preferably X represents hydroxyl in the (S)-configuration.

Group B is derived from a pyrimidine or purine base. When derived from a pyrimidine base it can be represented by formula III:



(III)

wherein X represents OH, NH_2 or NHQ,

Q is OH or C_{1-5} alkyl,
Y is H, F, Cl, Br, I, C_{1-5} alkyl, haloethyl or CH=CH-R wherein R represents halogen or C_{1-5} alkyl and haloethyl with 1-4 F, Cl or Br atoms.

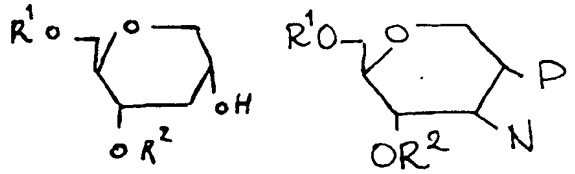
When B is a heterocyclic ring which is derived from a purine base it can be an adenine, guanine, hypoxanthine or xanthine ring, optionally substituted by halogen, C_{1-5} alkyl or -CH=CH-R, wherein R represents hydrogen, halogen or C_{1-5} alkyl.

In addition, aza, deaza, deoxy or deamino analogues of each of the said heterocyclic rings, optionally with one or more of above mentioned substituents, can be present in the compounds of formula I.

Substituents R^1 and X have the designation as stated above.

Chemical synthesis

The nucleoside analogues of the present invention can be prepared in different ways. In a preferred method the corresponding (R^1, R^2) substituted 1,5-anhydrohexitol ring protected in appropriate manner is first produced with a hydroxyl residue in its 2-position in the (R) configuration (formula IV).



(IV) (XIII)

Activation with a leaving group provides nucleophile replacement with a purine or pyrimidine base, followed by deprotection of the desired nucleoside analogues (formula XIII wherein P represents -OR and N is hydroxyl, and wherein R represents a leaving group (such as SO_2CH_3, $SO_2C_6H_4CH_3$, $SO_2C_6H_4Br$), or P and N are components of an epoxidization for introducing the heterocyclic ring in the 2-position followed by removal of the hydroxyl group in the 3-position). Substituents in 4-position (position X in formula I) can be introduced in accordance with classical and known reaction schedules which are used for introduction of substituents X in formula II (2'-deoxypentofuranosyl nucleoside analogues).

In similar manner the preparation of the 1,5-anhydrohexitol ring can be performed in different ways. A preferred method is elucidated in the following schedule.

The synthesis begins with glucose (V) which is converted into tetra-O-acetyl-glucopyranosyl bromide (VI) in accordance with Kartha et al., J. Carbohydrate Chem. 9, 777-781 (1990).

Reduction is achieved with tri-n-butyltinhydride [which can be generated in situ from bistributyltinoxide and a polymethylhydrosiloxane, in accordance with Kocienski et al., Carbohydrate Res. 110, 330-332 (1982)], or with other reducing means which provide compound VII. Removal of the acetyl groups with sodium methoxide is followed by introduction of a benzylidene protective group, analogously of protection of methylglucoside [Methods in Carbohydrate Chemistry, vol. 2, p. 208] whereby compound VIII is obtained. Selective reaction of the hydroxyl in position 2 is feasible after previous activation with dibutyltinoxide. Position 2 can either be selectively protected, for instance as an ester (for example R = $CH_3C_6H_4CO$) or can be functionalized with a leaving group (for example R = $CH_3C_6H_4SO_2$, formula IX). The hydroxyl group in position 3 is subsequently removed [(for instance by Barton deoxygenation, see Barton et al., Tetrahedron Lett. 30, 2619-2622 (1989)] whereby the compound of formula X is obtained.

Coupling of the purine or pyrimidine base can be performed substantially in three ways:

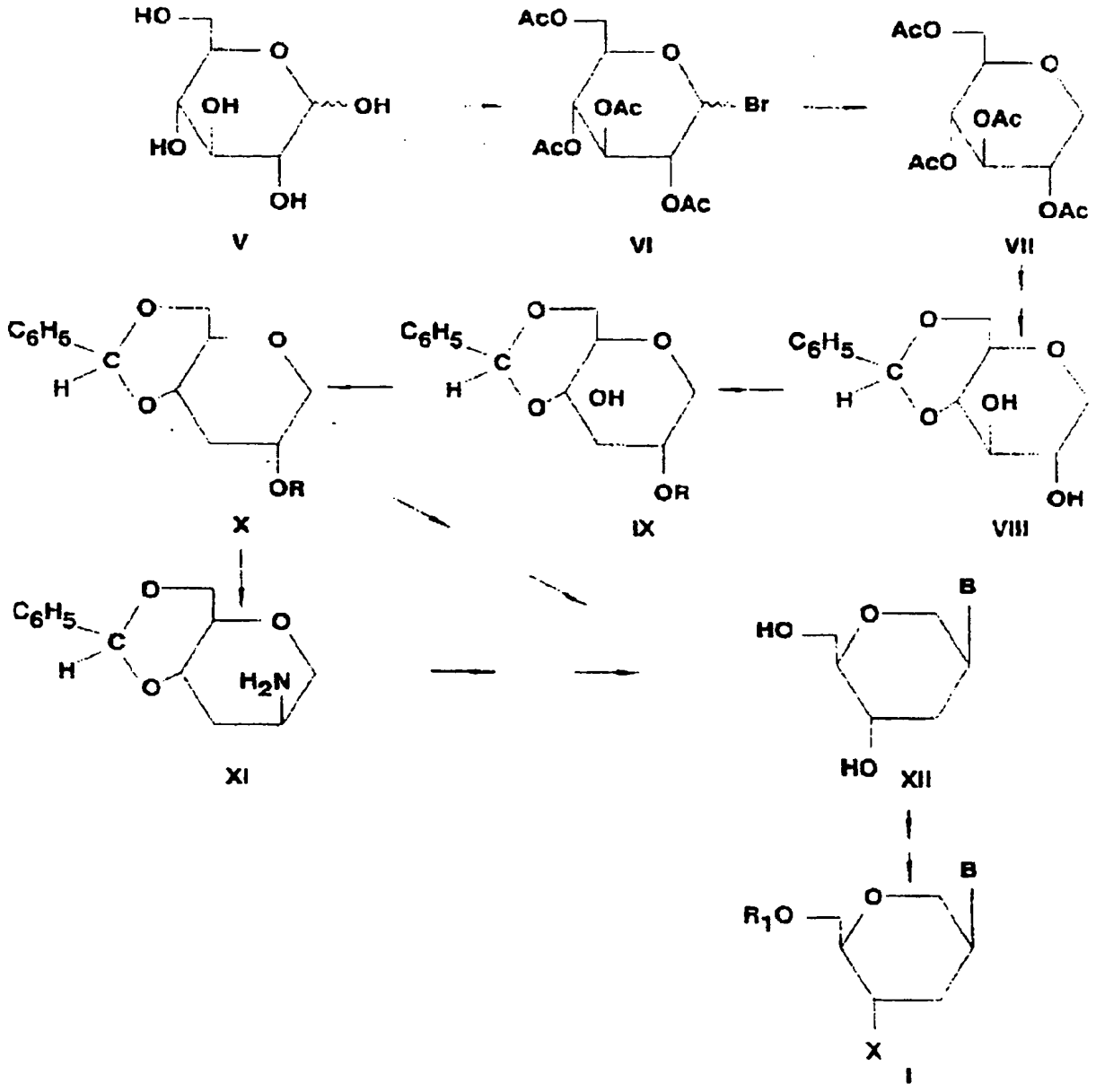
a) by nucleophile replacement of the leaving group in position 2 with the respective purine or pyrimidine base. Compare for example Medich et al., Tetrahedron Lett. 28, 4131-4134 (1987).

b) by hydrolysis of the temporary protective group R, whereby the compound of formula X is obtained, wherein R = H, followed by alkylizing of the purine or pyrimidine base under modified Mitsunobu conditions. Compare Jenny et al., Tetrahedron Lett. 32, 7029-7032 (1991).

c) by constructing the heterocyclic base by standard procedures after introduction of an amine function in the (S) configuration (formula XI). For a survey of the construction of the base for a carbocyclic amine compare Marquez and Lim, Medicinal Res. Rev. 6, 1-40 (1986).

The resulting product of formula I can be purified by standard procedures. In the alternative case a hydroxyl group in the 3-position can be removed during reduction after introduction of the base in the 2-position.

Pharmaceutically acceptable salts and esters of the nucleoside analogues of formula I can further be prepared in conventional manner.



As stated above, the nucleoside analogues of the present invention generally have anti-viral activities against herpes viruses, pox viruses and related viruses, such as herpes simplex virus 1, herpes simplex type 2, varicella zoster virus, cytomegalo virus and vaccinia virus. In this manner they can advantageously be used for treating the diseases caused by such viruses in human and veterinary medicine.

Pharmaceutical compositions

Pharmaceutical compositions containing the nucleoside analogues of the invention as an active ingredient can take the form of tablets, capsules, powders, suspensions, solutions, emulsions as well as salves and creams, and can be used for parenteral (intravenous, intradermal, intramuscular, intrathecal etc.) injections, oral, rectal, intravaginal and intranasal administering or for local application (for instance on skin injuries, mucosa and eyes). Such compositions can be prepared by combining the active ingredient(s) with pharmaceutically acceptable excipients normally used for this purpose. Such excipients can comprise aqueous and non-aqueous solvents, stabilizers, suspension agents, dispersing agents, moisturizers and the like, and will be known to the skilled person in the pharmaceutical field. The composition may further contain likewise suitable additives such as for instance polyethylene glucoles and, it necessary, colorants, fragrances and the like.

The pharmaceutical compositions will preferably contain at least 0.1 volume % by weight of the active ingredient. The actual concentration will depend on the disease and the chosen administering route. In general this concentration will lie between 0.1 and 100% for the above applications and indications. The dose of the active ingredient to be administered can further vary between 0.1 mg and 100 mg per kg body weight, preferably between 0.1 mg and 50 mg per kg body weight, and most preferably between 0.5 mg and 20 mg per kg body weight.

The desired dose is preferably presented in the form of two, three, four, five, six or more sub-doses which are administered at appropriate intervals per day. These subdoses can be administered in the form of dosage units containing for instance from 1 to 1500 mg, preferably from 5 to 1000 mg and most preferably from 10 to 700 mg active constituent per dosage unit, and if the condition of the patient permits the dose can, by way of alternative, be administered as a continuous infusion.

Examples

The compounds according to the invention as well as their chemical synthesis and the preparation of the starting materials are further illustrated in the following examples, which are not however intended to limit the invention.

EXAMPLES

2,3,4,6-Tetra-O-acetyl-α-D-glucopyranosylbromide (1)

This compound was prepared in accordance with Kartha et al., and Jennings, H., J. Carbohydr. Chem. 9, 777-781 (1990).

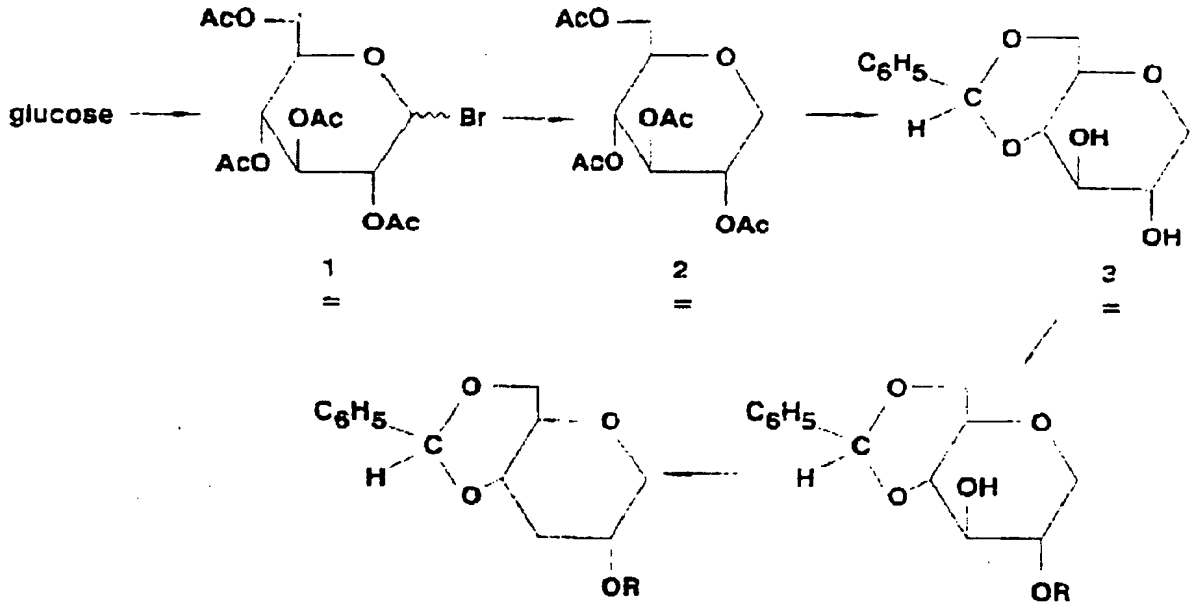
2,3,4,6-Tetra-O-acetyl-1,5-anhydro-D-glucitol (2)

To a solution of 44.8 g of compound 1 (109 mmol) in dry diethylether was added 55 ml bistributyltinoxide (109 mmol) and an equal quantity of polymethylhydrosiloxane (55 ml). The mixture was stirred at room temperature under nitrogen. TLC evaluation after 3 hours (CH_2Cl_2 - MeOH 98:2) showed that all the 2,3,4,6-Tetra-O-acetyl-α-D-O-glucopyranosylbromide was converted into a more polar product. A solution of 15.80 g KF (2.5 eq, 272 mmol) in water was then added and the mixture stirred vigorously for 15 minutes. The Bu_3SnF precipitate was filtered and washed with diethylether. After separation of the water the ether layer was dried above anhydrous Na_2SO_4 and evaporated dry. The compound *of* the title (2) (30.06 g, 90.5 mmol; 83% yield) was obtained after chromatographic purification [1) CH_2Cl_2 hexane 50:50; 2) CH_2Cl_2].

1,5 Anhydro-4,6-O-benzylidene-D-glucitol (3)

Removal of the protective groups of 2 was achieved by treating 30.06 g (90.5 mmol) of compound 2 with 400 ml 0.1 N NaOMe for 2 hours at room temperature. The mixture was neutralized with acetic acid and evaporated dry. After CO evaporation with toluene, 12.4 g (91 mmol) freshly dried $ZnCl_2$ and 46.5 ml (455 mmol) benzaldehyde were added and the suspension stirred vigorously for i to 2 days at room temperature.

The mixture was poured into coid water and extracted three times with ethyl acetate. The combined organic layer was dried on anhydrous Na_2SO_4. After filtration and removal of the solvent the excess benzaldehyde was partially removed under vacuum at 70°C (oil pump). The solid residue was further purified by washing on a glass funnel with n-hexane followed by chromatographic purification [1) hexane - HC_2Cl_2 1:1; 2) CH_2Cl_2; 3) CH_2Cl_2 - MeOH 98:2] whereby 17.1 g (68 mmol) 75% yield) of compound 3 was obtained.



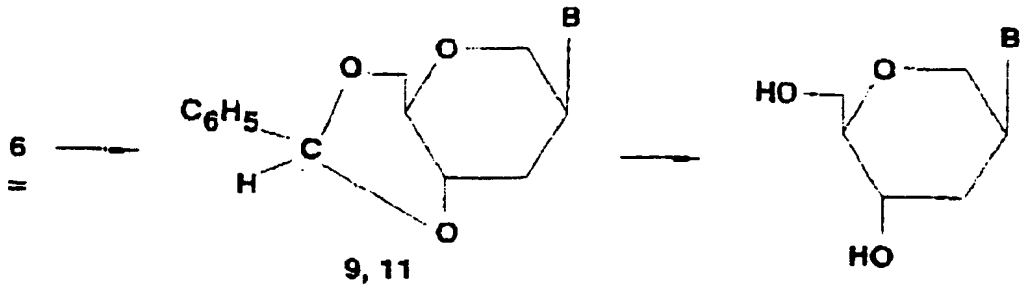
6 R = $CH_3C_6H_4SO_2$

7 R = $CH_3C_6H_4CO$

8 R = H

4 R = $CH_3C_6H_4SO_2$

5 R = $CH_3C_6H_4CO$



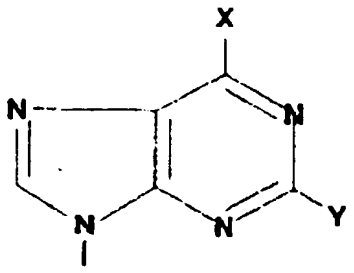
9, 11

15, 16

10,12,13,14

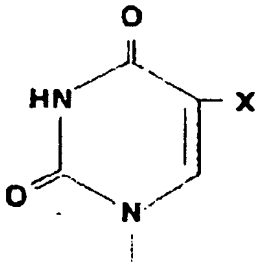
17,18

B =

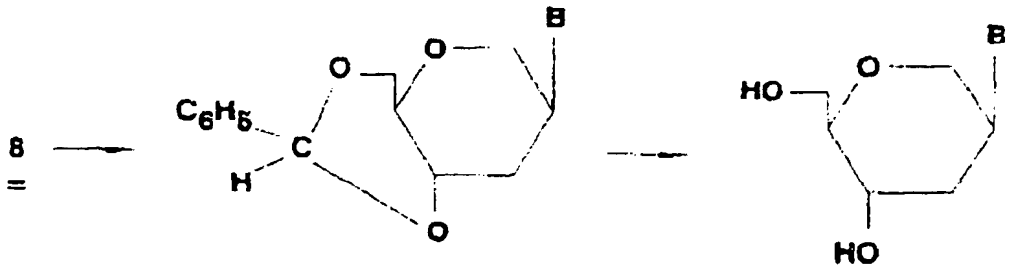


9, 10 = =	X = NH_2,	Y = H
11,12 = =	X = Cl,	Y = NH_2
13 =	X = OH,	Y = NH_2
14 =	X = OH,	Y = H

B =



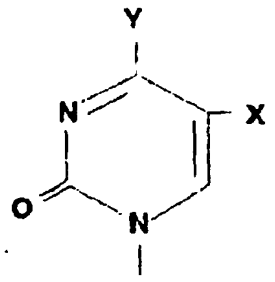
15, 17 = =	X = CH_3
16,18 = =	X = I



15, 19 = =

17, 20 = =

B =



15, 17 = =	X = CH_3 ,	Y = OH
19, 20 = =	X = H ,	Y = NH_2

1,5-Anhydro-4,6-O-benzylidene-2-O-p-toluenesulphonyl-D-glucitol (4)

The glucitol derivative 3 (8.5 g, 33.67 mmol) and dibutyltinoxide (8.38 g, 367 mmol) were suspended in 250 ml benzene. The mixture was heated under reflux for 16 hours with azeotropic removal of water. After removal of the volatile substances the residue was dissolved in 150 ml anhydrous dioxane and 7.06 g (37.04 mmol) p-toluene-sulphonylchloride was added. The mixture was heated to 50°C for 6 hours, which resulted in a quantitative conversion to a less polar product. The mixture was concentrated, adsorbed on celite and purified by column chromatography (CH_2Cl_2 - hexane, 1:1; CH_2Cl_2;) to a yield of 11.22 g (27.6 mmol, 82%) of compound 4 as a white powder.
EIMS m/e : 406 (M^+)
400 MHz ^1H NMR (DMSO-d_6) δ 2.42 (s, 3H, CH_3), 3.35-3.42 (m, H-4, H-5), 3.49 (t, J=11Hz, 1H, H-1α), 3.61 (m, 1H, H-6), 3.67 (m, 1H, H-3), 3.87 (dd, J=5.5Hz and 11Hz, 1H, H-1β), 4.14-4.25 (m, 2H, H-2, H-6'), 5.05 (s, 1H, PhCH), 5.12 (d, J=5.5Hz, 1H, OH), 7.35-7.50 (m, 7H, arom-H), 7.85 (m, 2H, arom-H)ppm.
90MHz ^{13}C NMR (DMSO-d_6) δ 21.0 (CH_3), 66.9, 67.6 (C-1, C-6), 70.7, 70.8 (C-3, C-5), 79.2, 80.4 (C-2, C-4), 100.7 (PhCH) + arom.

1,5-Anhydro-4,6-O-benzylidene-2-O-p-toluoyl-D-glucitol (5)

A suspension of the sugar derivative 3 (8.5 g, 33.67 mmol) and dibutyltinoxide (8.38 g, 33.67 mmol) in 250 ml benzene was boiled under reflux for 16 hours with azeotropic removal of water. The solution was concentrated and 150 ml dry dioxane was added. p-Toluoyl chloride (4.44 ml, 33.67 mmol) was added in droplets and the mixture was stirred for 5 hours at room temperature. The mixture was concentrated, adsorbed on celite and purified by column chromatography to a yield of 9.73 g (26.30 mmol, 78%) of compound 5 as a white powder.

1,5-Anhydro-4,6-O-benzylidene-3-deoxy-2-O-p-toluenesulphonyl-D-ribohexitol (6)

A) 11.22 g (27.6 mmol) of the tosylated sugar 4 and 23.60 g (193 mmol) of 4-dimethylaminopyridine (DMAP) were dissolved in 400 ml dry CH_2Cl_2. The reaction mixture was cooled to -40°C and during vigorous stirring 2.53 ml thiophosgene (33.12 mmol) was added. The mixture was brought to room temperature. After stirring for 1 hour 6.30 g (38.64 mmol) 2,4-dichlorophenol was added and stirring continued for 2 hours. The mixture was poured into 300 ml 1 M KH_2PO_4 and extracted twice with CH_2Cl_2. The organic layers were dried (Na_2SO_4), the volatile substances removed under vacuum and the residue purified by flash chromatography (hexane/CH_2Cl_2 8:2 to CH_2Cl_2)
B) the obtained thiocarbonyl compound was dissolved in 300 ml anhydrous toluene. After fast boiling the solution for 10 minutes with N_2, 7.84 ml (29.15 mmol) tri-n-butyltinhydride and 325 mg (2 mmol) 2,2'-azobis(2-methylpropionitrile) were added and the reaction mixture heated overnight at 80°C.

The mixture was evaporated and purified on silica gel with a yield of 6.90 g (17.67 mmol, 64%) of compound 6.
CMIS (NH_3) m/e : 391 (MH^+)

1,5-Anhydro-4,6-O-benzylidene-3-deoxy-2-O-p-toluonyl-D-ribohexitol (7)

The reaction was performed as described for the synthesis of compound 6. Treating of 9.73 g (26.30 mmol) of the toluoylated hexitol 5 provided 6.79 g (19.73, 75%) of compound 7 after chromatographic purification.

1,5-Anhydro-4,6-O-benzylidene-3-deoxy-D-glucitol (8)

Removal of the toluoyl group of compound 7 was achieved by treating 6.79 g (19.73 mmol) thereof with 300 ml 0.1 M NaOMe for 4 hours at room temperature. After neutralizing and evaporation of the volatile substances the residue was purified by column chromatography (CH_2Cl_2 - MeOH, 99:1) with a yield of 3.72 g (15.81 mmol, 80%) of the above compound.

1,5-Anhydro-4,6-O-benzylidene-2-(adenin-9-yl)-2,3-dideoxy-D-arabinohexitol (9)

A mixture of 1.35 g (10 mmol) adenine, 400 mg sodium hydride (60% dispersion, 10 mmol) and 529 mg (2 mmol) 18-crown-6 in 60 ml dry DMF was stirred for 1 hour at 80°C. After adding a solution of 1.95 g (5 mmol) of compound 6 in 30 ml anhydrous DMF the stirring was continued for 16 hours at 100°C. The reaction mixture was cooled and evaporated dry. the residue was dissolved in ethylacetate (100 ml) and the organic phase was washed with saturated $NaHCO_3$ solution (50 ml) and H_2O (2 x 25 ml), dried and evaporated dry. The solid residue was purified by column

chromatography (CH_2Cl_2 - MeOH, 97:3) with a yield of 989 mg (2.8 mmol, 56% yield) of compound 9. A quantity of 190 mg (0.49 mmol, 9%) of the tosylate 6, which had not reacted, was recovered.
UV (MeOH) : λ_{max} 262 nm (ε = 11300)
MS (m/e) : 353 (M^+)
^1H NMR ($CDCl_3$ + DMSO-d_6) δ 2.0-2.6 (m, H-3', H-3"), 3.5-4.55 (m, 5H), 4.94 (m, 1H), 5.57 (s, PhCH), 7.10 (br, NH_2), 7.35 (m, 5H, Ph), 8.19 (s), 8.27 (s) (H-2, H-8)ppm.
^{13}C NMR ($CDCl_3$ + DMSO-d_6; internal ref. TMS)) δ 32.6 (C-3'), 50.4 (C-2'), 68.3, 69.1 (C-1', C-6'), 73.6, 74.0 (C-4', C-5'), 101.2 (PhCH); 119.0 (C-5), 126.1,127.8, 128.6, 137.6 (Ph), 139.0 (C-8), 149.5 (C-4), 152.5 (C-2), 156.1 (C-6)ppm.

1,5-Anhydro-2-(adenin-9-yl) 2,3-dideoxy-D-arabinohexitol (10)

The benzylidene moiety of compound 9 was hydrolyzed by heating 989 mg (2.8 mmol) thereof in 100 ml 80% acetic acid at 80°C for 3 hours. After evaporation and co-evaporation with toluene the residue was dissolved in water and washed with diethylether. The water layer was evaporated and the residue crystallized from MeOH-Et_2O with a yield of 602 mg (2.27 mmol, 81% yield) of compound 10.
smp : 237-239°C
UV (MeOH) : λ_{max} 261 nm (ε = 13500)
CIMS (NH_3) m/e : 266 (MH^+), 136 (BH_2^+)
^1H NMR (DMSO-d_6) δ 1.7-2.4 (m, H-3', H-3'), 3.2-4.3 (m, 6H), 4.53-5.02 (m, H-5', 4'-OH, 6'-OH), 7.25 (br s, NH_2) 8.16 (s), 8.31 (s) (H-2, H-8)ppm.
^{13}C NMR (DMSO-d_6) δ 36.0 (C-3'), 50.2 (C-2'), 60.6, 60.9 (C-4', C-6'), 68.1 (C-1'), 83.1 (C-5'), 118.2 (C-5), 139.7 (C-8), 149.4 (C-4), 152.5 (C-2), 156.1 (C-6)ppm.
Anal.

1,5-Anhydro-4,6-O-benzylidene-2-(2-amino-6-chloropurin-9-yl)-2,3-dideoxy-D-arabinohexitol (11)

The 1,5-anhydrohexitol 6 (1.56 g, 4 mmol) and 848 mg (5 mmol) 2-amino-6-chloropurine were dissolved in 30 ml anhydrous DMF to which 830 mg (6 mmol) anhydrous potassium carbonate and 530 mg (2 mmol) 18-crown-6 were added. The mixture was stirred for 5 hours at 120°C after which the volatile substances were removed under vacuum and the residue adsorbed on silica gel. Purifying produced 295 mg (0.76 mmol, 90%) of the compound 11.
^1H NMR ($CDCl_3$) δ 1.86-2.32 (m, H-3') 2.45-2.75 (m, H-3"), 3.5-3.9 (m, 3H), 4.07 (dd, J=2.6Hz and 13Hz, 1H), 4.34 (m, 2H), 4.77 (m, 1H), 5.30 (s, NH_2), 5.48 (s, PhCH), 7.2-7.5 (m, Ph), 8.27 (s, H-8)ppm.
^{13}C NMR ($CDCl_3$) δ 32.8 (C-3'), 50.8 (C-2'), 68.8, 69.2 (C-6', C-1'), 73.7, 74.6 (C-4', C-5'), 101.9 (PhCH), 125.9, 128.1, 128.9, 137.0, (Ph), 126.1 (C-5), 141.1 (C-8), 151.5 (C-6), 153.5 (C-4), 159.0 (C-2)ppm.

1,5-Anhydro-2-(2-amino-6-chloropurin-9-yl)-2,3-dideoxy-D-arabinohexitol (12)

The obtained compound 11 (295 mg, 0.76 mmol) was heated in 50 ml 80% acetic acid at 80°C to complete hydrolysis of the benzylidene moiety. Evaporation and co-evaporation with toluene left behind an oil which was purified on silica gel (CH_2Cl_2 - MeOH, 9:1). The product which precipitated after concentration of the eluate provided 145 mg (0.48 mmol, 63%) of compound 12.
UV (MeOH) : λ_{max} 224 (27000), 249 (6100), 310 (8000) nm. ^1H NMR (DMSO-d_6) δ 1.7-2.5 (H-3', H-3"), 3.94 (J=11Hz,), 4.18 (J=12Hz), 4.67 (t, J=5.5Hz, 6'-OH), 4.95 (d,J=5.2Hz, 4'-OH), 6.95 (s, NH_2), 8.30 (s, H-8)ppm.
^{13}C NMR (DMSO-d_6) δ 35.7 (C-3'), 50.3 (C-2'), 60.5, 60.7 (C-4', C-6'), 67.8 (C-1'), 83.0 (C-5'), 123.0 (C-5), 141.9 (C-8), 149.5 (C-6), 154.0 (C-4), 159.8 (C-2)ppm.

1,5-Anhydro-2-(guanin-9-yl)-2,3-dideoxy-D-arabinohexitol (13)

A mixture of 145 mg (0.48 mmol) of compound 12 and 0.5 ml of a suspension of adenosine deaminase in 100 ml 0.05 M phosphate buffer, pH 7.5, was incubated for 4 hours at 30°C. The reaction mixture was concentrated to about 15 ml and the precipitate filtered off. Recrystallization from water provided 50 mg analytically pure compound 13. The filtrates were placed onto an XAD column (25 x 2 cm), which was eluted with water followed by MeOH-water (3:1). Evaporation gave an extra 70 mg of compound 13 as a white product to a total of 0.43 mmol (89%).
smp
UV (MeOH)
CIMS (iC_4H_{10}) m/e : (282 (MH^+)
^{1}HNMR (DMSO-d_6) δ 4.52 (br, 6'-OH), 4.9 (br, 4'-OH), 6.56 (br, NH_2), 7.87 (s, H-8)ppm.
^{13}C NMR (DMSO-d_6) δ 36.3 (C-3'), 50.2 (C-2'), 61.0, 61.2 (C-4', C-6'), 68.4 (C-1'), 83.2 (C-5'), 116.3 (C-5), 136.9 (C-

8), 151.5 (C-4), 154.1 (C-2) 157.9 (C-6)ppm.
Anal. ($C_{11}H_{15}N_5O_4$)
Calculated: C, 46.97; H, 5.38; N, 24.90
Found: C, 46.73; H, 5.40; N, 24.58

1,5-Anhydro-2,3-dideoxy-2-(5-iodouracil-1-yl)-D-arabinohexitol (18)

A mixture of 2.60 g (10 mmol) of the sodium salt of 5-iodouracil [prepared in accordance with Colla t. et al., Eur. J. Med. Chem., 17, 569 (1982)], 1.95 g (5 mmol) crude tosylate 6 and 528 mg (2 mmol) 18-crown-6 in 80 mg dry DMF was stirred at 100°C for 16 hours. The reaction mixture was cooled and evaporated dry. The residue was dissolved in 100 ml EtOAc and the organic layer was washed successively with saturated $NaHCO_3$ solution (50 ml) and water (3 x 50 ml), dried and evaporated dry. Column chromatography (CH_2Cl_2 - MeOH, 98:2) produced 958 mg (2.1 mmol, 42%) yield of compound 16 in the form of an oil and 371 mg (0.95 mmol) of the tosylate, which had not reacted, was recovered.

The obtained oil was heated in 100 ml 80% acetic acid at 80°C to complete hydrolysis of the benzylidene moiety. The mixture was evaporated and co-evaporated with toluene and purified by column chromatography (CH_2Cl_2 - MeOH, 90:10) with a yield of 408 mg (1.11 mmol, 53%) of the compound 18 which crystallized out of MeOH.
smp 219-220°C
UV (MeOH) : λ_{max} 282 nm
CIMS (NH_3) m/e : 369 (MH^+)
^{1}H NMR (DMSO-d_6) δ 1.53-2.42 (n, H-3, H-3'), 2.8-4.2 (m, 6H), 4.53 (m, 1H), 8.47 (s, H-6)ppm.
^{13}C NMR (DMSD-d_6) δ 35.3 (C-3'), 51.4 (C-2'), 60.7, 61.1 (C-4', C-6'), 67.2, (C-1'), 68.3 (C-5), 82.7 (C-5'), 147.9 (C-6), 150.9 (C-2), 160.9 (C-4)ppm.
Anal. ($C_{10}H_{13}N_2O_5I$ x 0.75 H_2O) :
Calculated: C, 31.47; H, 3.83; N, 7.34
Found: C, 31.83; H, 4.14; N, 7.03

1,5-Anhydro-2,3-dideoxy-2-(thymin-1-yl)-D-arabinohexitol (17)

The above compound was synthesized in the same manner from compound 6 but in very moderate yields. Better results are obtained when the alcohol 8 is used as starting point.

A suspension of 2.40 g (10.46 mmol) of N^3-benzoylthymine [prepared in accordance with Cruickshank et al., Tetrahedron Lett. 25, 681-684 (1984)], 1.23 g (5.23 mmol) of the alcohol 8 and 3.43 g (13.08 mmol) of triphenylphosphine in 100 ml anhydrous dioxane was treated with 2.06 ml (13.08 mmol) diethylazodicarboxylate (DEAD) in 15 ml anhydrous THF. The solution was stirred overnight at room temperature whereafter the volatile substances were removed under vacuum. The residue was resuspended in 100 ml methanol saturated with ammonia. Evaporation and co-evaporation with toluene left behind an oil which was purified on silica gel (CH_2Cl_2 - MeOH, 98:2). This provided 3.5 g of crude compound 15 which also contained hydrazine dicarboxylate.

The crude compound 15 was resuspended in 50 ml 80% acetic acid and heated at 80°C for 5 hours. After evaporation and co-evaporation with toluene the residue was dissolved in water and extracted with ether. The water layer was concentrated and purified on silica gel (CH_2Cl_2 - MeOH, 93:7). Crystallization out of MeOH-Et_2O provided 671 mg of the compound 17 as white crystals (2.62 mmol, 50% total yield).
smp 169-171°C
UV (MeOH) : $_{max}$ 272 nm (9500)
CIMS (iC_4H_{10}) m/e : 257 (MH^+)
^{1}H NMR (DMSO-d_6) δ 1.77 (s, CH_3), 1.6-2.5 (m, H-3', H-3"), 3.05-3.30 (m, 1H), 3.4-4.1 (m, 5H), 4.52 (m, 1H), 4.65 (t, J=5.7Hz, 6'-OH), 4.89 (d, J=5Hz, 4'-OH) 7.88 (s, H-6), 11.25 (br, NH)ppm.
^{13}C NMR (DMSO-d_6) δ 12.3 (CH_3), 35.2 (C-3'), 50.1 (C-2'), 60.3, 60.8, (C-4', C-6'), 66.9 (C-1'), 82.4 (C-5'), 108.3 (C-5), 138.9 (C-6), 150.9 (C-2), 163.8 (C-4)ppm. Anal. ($C_{11}H_{16}N_2O_5$ x 0.5 H_2O) :
Calculated: C, 49.81; H, 6.46; N, 10.56
Found: C, 49.84; H, 6.52; N, 10.55

1,5-Anhydro-2-(cytosin-1-yl)-2,3-dideoxy-D-arabinohexitol (20)

A suspension of 2.15 g (10 mmol) of N^3-benzoylcytosine [prepared in accordance with Brown et al., J. Chem. Soc. 2384 (1956)], 1.16 g (5 mmol) of the alcohol 8 and 3.28 g (12.5 mmol) of triphenylphosphine in 100 ml anhydrous dioxane was treated with 1.97 ml (12.5 mmol) diethylazodicarboxylate in 20 ml anhydrous THF for 15 hours at room temperature. After removal of the volatile substances the residue was resuspended in 100 ml EtOAc and washed twice

with 50 ml water.

The organic layer was dried on anhydrous Na_2SO_4, evaporated and adsorbed on silica gel. Purifying by column chromatography produced 800 mg (1.85 mmol, 37%) of the crude 1,5-anhydro-4,6-0-benzylidene-2,3-dideoxy-2- (N^4-benzoylcytosin-1-yl)-D-arabinohexitol.

The benzoyl group was removed by treatment with 70 ml NH_3/MeOH for 5 hours at room temperature. Evaporation left an oil which was purified on silica gel (CH_2Cl_2 - MeOH, 98:2) to a yield of 400 mg of the debenzoylated derivative as an oil.

The obtained oil was treated with 50 ml 80% acetic acid at 80°C for 5 hours. After evaporation and co-evaporation with toluene the residue was dissolved in water and washed with diethylether. The water layer was evaporated and the precipitate crystallized out of NeOH-Et_2O with a yield of 234 mg of the compound 20 (0.97 mmol, 80%).

UV (MeOH) :λ_{max} 276 nm (8200)

CIMS (iC_4H_{10}) m/e : 242 (MH^+)

^{1}H NMR (DMSO-d_6) δ 1.47-1.87 (m, H-3), 1.91-2.28 (m, H-3'), 2.95-3.30 (m, 1H, H-2), 3.35-4.10 (m, 5H), 4.52 (m, 2H, 6'-OH + H-5'), 4.85 (d, J=4.8Hz, 4'-OH), 5.66 (d, J-7.5Hz, H-5), 6.99 (s, NH_2), 7.97 (d, J=7.5Hz, H-6)ppm.

^{13}C NMR (DMSO-d_6) δ 35.7 (C-3'), 51.5 (C-2'), 61.0, 61.2 (C-4', C-6'), 67.9 (C-1'), 82.9 (C-5'), 93.7 (C-5), 144.3 (C-6), 156.3 (C-2), 165.7 (C-4)ppm.

Anal. ($C_{10}H_{15}N_3O_4$)

Calculated: C, 49.79; H, 6.27; N, 17.42

Found: C, 49.85; H, 6.27; N, 17.20

Anti-viral tests

The anti-viral activity of the compounds according to the invention in respect of the herpes virus and related viruses is illustrated by the following tests. In these tests the effect was determined of the 1,5-anhydrohexitol nucleoside analogues according to the invention on the growth and yield of the virus in cell cultures.

The compounds used are described in the examples together with a number of well known anti-herpes agents from the prior art, that is, BVDU or E-5-(2-bromovinyl)-2'-deoxyuridine, Ribavirin or 1-ribofuranosyl-3-carbamoyl-1,2,4-triazol, (S)DHPA or (S)-9-(2,3-dihydroxypropyl)-adenine and C-c^3 Ado or carbocyl 3-deaza adenosine.

The compounds were tested against herpes simplex virus type 1 (HSV-1), herpes simplex virus 2 (HSV-2) and vaccinia virus (VV). These viruses were cultured in human embryonal skin muscle (E_6SM) fibroblast cell cultures.

The tests were based on the inhibition of virus-induced cytopathogenisis in cell cultures. A standard procedure is described by De Clercq et al., J. Infect. Dis. 141, 463 (1980) which is incorporated herein by way of reference.

Test 1

In this test the inhibiting activity of the test compounds against viruses was measured in E_6SM cell cultures. The cells were cultured to confluence in microtitre (R) plates and then inoculated with 100 $CCID_{50}$ virus, wherein a $CCID_{50}$ of the virus corresponds with the virus dose required to infect 50% of the cell cultures. After a virus adsorption period of an hour remaining virus was removed and the cell cultures incubated in the presence of different concentrations of the test compounds (varying from 0.001 µg/ml to 400 µg/ml). For each virus cell system the ED_{50} was determined, that is, the concentration of the compound required to suppress the cytopathic effect of the virus by 50%. This cytopathic effect was noted as soon as it reached completion in the non-treated, virus-infected cell cultures. In addition the minimum cytotoxic concentration of each compound was measured. The results are shown in table I.

Test 2

Further, the inhibiting effect of the test compounds on virus multiplication in E_6SM cell cultures was measured making use of herpes simplex viruses missing a specific thymidine kinase. Three different strains were used: TK^- Cheng, TK^- Field and a clinically isolated strain VMW/837. The results are shown in table II.

Table I

Cytotoxicity and anti-viral activity of nucleoside analogues in human embryonal skin muscle (E_6SM) fibroblast cultures.				
Compound	Minimum cytotoxic concentration[a] (μg/ml)	Minimum inhibiting concentration[b] ED_{50} (μg/ml)		
		HSV-1 (KOS)	HSV-2 (G)	VV
10	>400	7	7	20
13	>400	0.2	0.1	2
18	>400	0.07	0.07	150
17	>400	40	150	>200
20	>400	0.7	0.04	0.7
IDU	>400	0.2	0.2	0.2
BVDU	>400	0.004	10	0.2
(S)-DHPA	>400	70	300	20
Ribavirin	>400	70	70	70
C-c^{3}Ado	>400	>400	40	0.7

[a]Required to cause a microscopically detectable change in the normal cell morphology

[b]Required to reduce the virus-induced cytopathogenisis by 50%

Table II

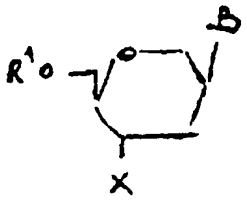
Cytotoxicity and anti-viral activity of nucleoside analogues in human embryonal skin muscle (E_6SM) fibroblast cultures.				
Compound	Minimum cytotoxic concentration[a] (μg/ml)	Minimum inhibiting concentration[b] ED_{50} (μg/ml)		
		HSV-1 TK$^-$Cheng C 158/77	HSV-2 TK$^-$Field C 137/101	VV VMW/837 #3
10	>400	150	70	20
13	>400	20	20	2
is	>400	>200	>200	1
17	>400	>200	>200	>200
20	>400	2	2	2
IDU	>400	10	10	7
BVDU	>400	10	10	4
(S)-DHPA	>400	400	>400	>400
Ribavirin	>400	>400	>400	>400
C-c^{3}Ado	>400	70	>400	>400

[a]Required to cause a microscopically detectable change in normal cell morphology

[b]Required to reduce virus-induced cytopathogenisis by 50%

Claims

1. 1,5-anhydrohexitol nucleoside analogues represented by the general formula I:



(I)

wherein:

B is a heterocyclic ring which is derived from the group which consists of pyrimidine and purine bases, and
X represents hydrogen, azido, F, Cl, Br, I, amino, $-NHR^2$, $-H(R^2)_2$, $-OR^2$, $-SR^2$ or CN;
wherein R^1 and R^2 are the same or different and hydrogen, alkyl, acyl or phosphate moieties are represented; wherein:

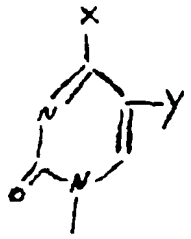
- alkyl is a saturated or unsaturated, substituted or non-substituted hydrocarbon radical with 1-20 carbon atoms and straight or branched chain, and
- acyl is an alkanoyl or aroyl moiety, wherein alkanoyl is an alkylcarbonyl radical, wherein alkyl is as described above and aroyl represents benzoyl, substituted benzoyl or naphtoyl;

or
X represents hydrogen and a double bond is situated between the 3- and 4- position of the 1,5-anhydrohexitol ring, in addition to pharmaceutical salts and esters thereof.

2. 1,5-anhydrohexitol nucleoside analogues as claimed in claim 1, **characterized in that** the hexitol has the D-configuration and the base moiety and the X substituent both have the (S)-configuration.

3. 1,5-anhydrohexitol nucleoside analogues as claimed in claim 1, **characterized in that** X represents hydroxyl in the (S)-configuration.

4. 1,5-anhydrohexitol nucleoside analogues as claimed in claim 1, **characterized in that** the heterocyclic ring derived from the group consisting of pyrimidine and purine bases is represented by the formula III:



(III)

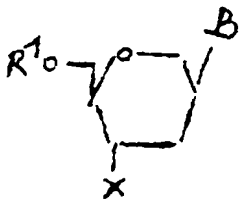
wherein:

X represents OH, NH_2, NHQ,
wherein:
Q represents OH or C_{1-5} alkyl;
Y represents H, F, Cl, Br, C_{1-5} alkyl, haloethyl or CH=CH-R, wherein R represents hydrogen, halogen or C_{1-5} alkyl and wherein haloethyl contains 1-4 F, Cl or Br atoms.

5. 1,5-anhydrohexitol nucleoside analogues as claimed in claim 1, **characterized in that** the heterocyclic ring derived from the group consisting of pyrimidine and purine bases is chosen from the group which consists of substituted and non-substituted adenine, guanine, hypoxanthine and xanthine, optionally substituted by halogen, C_{1-5} alkyl or -CH=CH-R, wherein R represents hydrogen, halogen or C_{1-5} alkyl.

6. 1,5-anhydrohexitol nucleoside analogues as claimed in claim 1, **characterized in that** aza-, deaza-, deoxy- or deamino- analogues of each of the heterocyclic rings, which if desired carry one or more substituents as defined in any of the foregoing claims, are present in the compounds of formula I.

7. Method for preparing 1,5-anhydrohexitol analogues represented by the general formula I



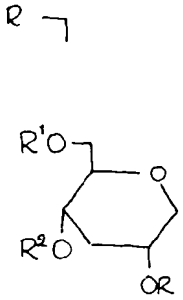
wherein:

B is a heterocyclic ring which is derived from the group which consists of pyrimidine and purine bases, and
X represents hydrogen, azido, F, Cl, Br, I, amino, - NHR^2, $-N(R^2)_2$, $-OR^2$, $-SR^2$ or CN;
wherein R^1 and R^2 are the same or different and hydrogen, alkyl, acyl or phosphate moieties are represented; wherein:

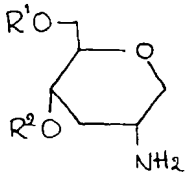
- alkyl is a saturated or unsaturated, substituted or non-substituted hydrocarbon radical with 1-20 carbon atoms and straight or branched chain, and
- acyl is an alkanoyl or aroyl moiety, wherein alkanoyl is an alkylcarbonyl radical, wherein alkyl is as described above and aroyl represents benzoyl, substituted benzoyl or naphtoyl;

in addition to pharmaceutical salts and esters thereof, which method comprises the steps of:

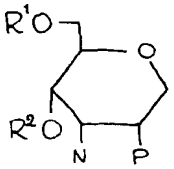
a) first manufacturing suitably protected 1,5-anhydrohexitol derivatives represented by the general formulas X, XI and XIII



X



XI



XIII

wherein R^1 and R^2 represent protective groups (for example R^1, R^2 = C_6H_5-CH=) and R represents a leaving function (for example R=SO_2CH_3, $SO_2C_6H_4CH_3$, $SO_2C_6H_4Br$) or R=H;
b) providing the purine or pyrimidine base by

i. coupling a purine or pyrimidine base,
either:

- to compounds of formula X by nucleophile replacement of the leaving group in position 2; or:
- by hydrolysis of the temporary protective group R, whereby the compound of formula X is obtained, wherein R = H, followed by alkalyzing the purine or pyrimidine base;

ii. by constructing a heterocyclic base by standard procedures after introduction of an amine function in the (S) configuration (formula XI); or
iii. using the derivative XIII, wherein P represents -OR and N is hydroxyl, and wherein R represents a leaving function as stated above, or
P and N are components of an epoxidization for introducing the heterocyclic ring in the 2-position followed by removal of the hydroxyl group in the 3-position;

c) if necessary converting the obtained compound to pharmaceutically acceptable salts or esters thereof.

8. Pharmaceutical composition with anti-viral activity against herpes viruses, pox viruses and related viruses, which composition comprises as an active ingredient a 1,5-anhydrohexitol nucleoside analogue of formula I, wherein:

B is a heterocyclic ring which is derived from the group which consists of pyrimidine and purine bases, and
X represents hydrogen, azido, F, Cl, Br, I, amino, $-NHR^2$, $-N(R^2)_2$, $-OR^2$, $-SR^2$ or CN;
wherein R^1 and R^2 are the same or different and hydrogen, alkyl, acyl or phosphate moieties are represented; wherein:

- alkyl is a saturated or unsaturated, substituted or non-substituted hydrocarbon radical with 1-20 carbon atoms and straight or branched chain, and
- acyl is an alkanoyl or aroyl moiety, wherein alkanoyl is an alkylcarbonyl radical, wherein alkyl is as described above and aroyl represents benzoyl, substituted benzoyl or naphtoyl;

or
X represents hydrogen and a double bond is situated between the 3- and 4- position of the 1,5-anhydrohexitol ring.

9. Pharmaceutical composition as claimed in claim 8, **characterised by** anti-viral activity against herpes-like viruses, which are chosen from the group which consists of herpes simplex virus type I (HSV-1), herpes simplex virus type 2 (HSV-2), Varicella zoster virus (VZV) and cytomegalo virus (CMV) as well as against pox viruses, for instance vaccinia virus (VV).

10. Pharmaceutical composition as claimed in claim 8, **characterized in that** the composition contains the active ingredient in a concentration between about 0.1 and 100% by weight.

11. Pharmaceutical composition as claimed in claim 9, **characterized in that** the composition takes the form chosen from the group consisting of powders, suspensions, solutions, sprays, emulsions, salves and creams.

12. 1,5-Anhydrohexitol nucleoside analogues of formula I as defined in claims 1-6 for use as an agent with biological activity.

13. 1,5-Anhydrohexitol nucleoside analogues of formula I as defined in claims 1-6 for use as an agent with anti-viral activity against herpes viruses, pox viruses and related viruses.

14. Use of 1,5-anhydrohexitol nucleoside analogues of formula I as defined in claim 1 for the preparation of a pharmaceutical composition with anti-viral activity against herpes viruses, pox viruses and related viruses.

15. 1,5-Anhydrohexitol nucleoside analogue of formula I as defined in claim 1, wherein

B is a heterocyclic ring which is derived from the group which consists of pyrimidine and purine bases, and
X represents hydrogen, azido, F, Cl, Br, I, amino, $-NHR^2$, $-N(R^2)_2$, $-OR^2$, $-SR^2$ or CN;
wherein R^1 and R^2 are the same or different and hydrogen, alkyl, acyl or phosphate moieties are represented; wherein:

- alkyl is a saturated or unsaturated, substituted or non-substituted hydrocarbon radical with 1-20 carbon atoms and straight or branched chain, and
- acyl is an alkanoyl or aroyl moiety, wherein alkanoyl is an alkylcarbonyl radical, wherein alkyl is as described above and aroyl represents benzoyl, substituted benzoyl or naphtoyl;

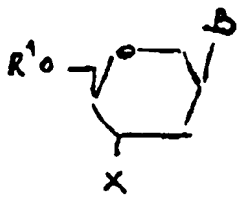
or

X represents hydrogen and a double bond is situated between the 3- and 4- position of the 1,5-anhydrohexitol ring, or a pharmaceutically acceptable salt or ester thereof

for use in a method for treating virus diseases caused by herpes viruses, pox viruses and related viruses.

Patentansprüche

1. 1,5-Anhydrohexitol-Nukleosidanaloge, dargestellt durch die allgemeine Formel I:



(I)

worin:

B ein heterocyclischer Ring ist, der aus der aus Pyrimidin- und Purinbasen bestehenden Gruppe abgeleitet ist, und

X Wasserstoff, Azido, F, Cl, Br, I, Amino, $-NHR^2$, $-N(R^2)_2$, $-OR^2$, $-SR^2$ oder CN darstellt;
wobei R^1 und R^2 gleich oder verschieden sind und Wasserstoff, Alkyl-, Acyl- oder Phosphatbestandteile darstellen; wobei:

- Alkyl ein gesättigter oder ungesättigter, substituierter oder unsubstituierter Kohlenwasserstoffrest mit 1-20 Kohlenstoffatomen und gerad- oder verzweigtkettig ist, und
- Acyl ein Alkanoyl- oder Aroylbestandteil ist, in dem Alkanoyl ein Alkylcarbonylrest ist, worin Alkyl wie oben beschrieben ist, und Aroyl Benzoyl, substituiertes Benzoyl oder Naphthoyl darstellt;

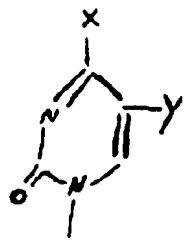
oder

X Wasserstoff darstellt und eine Doppelbindung zwischen der 3- und der 4-Position des 1,5-Anhydrohexitolrings angeordnet ist, zusätzlich zu pharmazeutischen Salzen und Estern hiervon.

2. 1,5-Anhydrohexitol-Nukleosidanaloge nach Anspruch 1, dadurch gekennzeichnet, daß das Hexitol in D-Konfiguration vorliegt und sowohl der Basenbestandteil als auch der X-Substituent die (S)-Konfiguration besitzen.

3. 1,5-Anhydrohexitol-Nukleosidanaloge nach Anspruch 1, dadurch gekennzeichnet, daß X Hydroxyl in der (S)-Konfiguration darstellt.

4. 1,5-Anhydrohexitol-Nukleosidanaloge nach Anspruch 1, dadurch gekennzeichnet, daß der, aus der aus Pyrimidin- und Purinbasen bestehenden Gruppe abgeleitete heterocyclische Ring, dargestellt ist durch die Formel III:



(III)

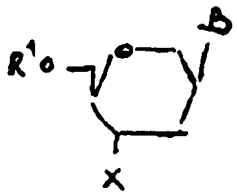
worin:

X OH, NH_2, NHQ ist,
worin:
Q OH oder C_{1-5}-Alkyl darstellt;
Y H, F, Cl, Br, C_{1-5}-Alkyl, Haloethyl oder CH=CH-R darstellt, worin R Wasserstoff, Halogen oder C_{1-5}-Alkyl darstellt und worin Haloethyl 1-4 F-, Cl- oder Br-Atome enthält.

5. 1,5-Anhydrohexitol-Nukleosidanaloge nach Anspruch 1, dadurch gekennzeichnet, daß der aus der Pyrimidin- und Purinbasen bestehenden Gruppe abgeleitete heterocyclische Ring, ausgewählt ist aus der Gruppe, bestehend aus Adenin, Guanin, Hypoxanthin und Xanthin, gegebenenfalls substituiert durch Halogen, C_{1-5}-Alkyl oder -CH=CH-R, worin R Wasserstoff, Halogen oder C_{1-5}-Alkyl darstellt.

6. 1,5-Anhydrohexitol-Nukleosidanaloge nach Anspruch 1, dadurch gekennzeichnet, daß Aza-, Deaza-, Deoxy- oder Deamino-Analoge jedes der heterocyclischen Ringe, die, wenn gewünscht, einen oder mehrere Substituenten, wie in einem der vorangehenden Ansprüche definiert, tragen, in den Verbindungen der Formel I vorhanden sind.

7. Verfahren zur Herstellung von 1,5-Anhydrohexitol-Nukleosidanalogen, dargestellt durch die allgemeine Formel I:



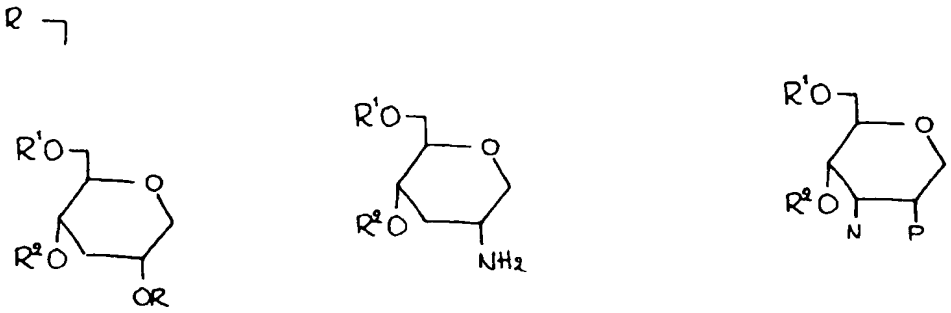
worin:

B ein heterocyclischer Ring ist, der aus der aus Pyrimidin- und Purinbasen bestehenden Gruppe abgeleitet ist, und
X Wasserstoff, Azido, F, Cl, Br, I, Amino, $-NHR^2$, $-N(R^2)_2$, $-OR^2$, $-SR^2$ oder CN darstellt;
wobei R^1 und R^2 gleich oder verschieden sind und Wasserstoff, Alkyl-, Acyl- oder Phosphatbestandteile darstellen; wobei:

- Alkyl ein gesättigter oder ungesättigter, substituierter oder unsubstituierter Kohlenwasserstoffrest mit 1-20 Kohlenstoffatomen und gerad- oder verzweigtkettig ist, und
- Acyl eine Alkanoyl- oder Aroylbestandteil ist, in dem Alkanoyl ein Alkylcarbonylrest ist, worin Alkyl wie oben beschrieben ist, und Aroyl Benzoyl, substituiertes Benzoyl oder Naphthoyl darstellt;

zusätzlich zu pharmazeutischen Salzen und Estern hiervon, wobei das Verfahren die Schritte umfaßt:

a) zuerst Herstellen geeignet geschützter 1,5-Anhydrohexitol-Derivate, dargestellt durch die allgemeinen Formeln X, XI und XIII



X XI XIII

in denen R^1 und R^2 Schutzgruppen darstellen (zum Beispiel R^1, R^2 = C_6H_5-CH=) und R eine Abgangsgruppe darstellt (zum Beispiel R=SO_2CH_3, $SO_2C_6H_4CH_3$, $SO_2C_6H_4Br$) oder R=H ist;

b) Bereitstellen der Purin- oder Pyrimidinbase durch

i. Kopplung einer Purin- oder Pyrimidinbase entweder:

- an Verbindungen der Formel X durch nucleophile Substitution der Abgangsgruppe in Position 2; oder:
- durch Hydrolyse der zeitweiligen Schutzgruppe R, wobei die Verbindung der Formel X erhalten wird, worin R = H ist, gefolgt von Alkalisierung der Purin- oder Pyrimidinbase;

ii. durch Konstruktion einer heterocyclischen Base durch Standardverfahren nach der Einführung einer Aminfunktion in der (S)-Konfiguration (Formel IX); oder
iii. Verwendung des Derivats XIII, in dem P -OR darstellt und N Hydroxyl ist, und worin R eine wie oben ausgeführte Abgangsgruppe darstellt, oder
P und N Bestandteile einer Epoxidierung zur Einführung des heterocyclischen Rings in 2-Position sind, gefolgt von der Entfernung der Hydroxylgruppe in 3-Position;

c) wenn notwendig, Umwandeln der erhaltenen Verbindung in pharmazeutisch akzeptable Salze oder Ester hiervon.

8. Pharmazeutische Zusammensetzung mit antiviraler Aktivität gegen Herpesviren, Pockenviren und verwandte Viren, wobei die Zusammensetzung als einen aktiven Bestandteil ein 1,5-Anhydrohexitol-Nukleosidanalogon der Formel I aufweist, worin:

B ein heterocyclischer Ring ist, der aus der aus Pyrimidin- und Purinbasen bestehenden Gruppe abgeleitet ist, und

X Wasserstoff, Azido, F, Cl, Br, I, Amino, -NHR^2, -$N(R^2)_2$, -OR^2, -SR^2 oder CN darstellt;
wobei R^1 und R^2 gleich oder verschieden sind und Wasserstoff, Alkyl-, Acyl- oder Phosphatbestandteile darstellen; wobei:

- Alkyl ein gesättigter oder ungesättigter, substituierter oder unsubstituierter Kohlenwasserstoffrest mit 1-20 Kohlenstoffatomen und gerad- oder verzweigtkettig ist, und
- Acyl eine Alkanoyl- oder Aroylbestandteil ist, in dem Alkanoyl ein Alkylcarbonylrest ist, worin Alkyl wie oben beschrieben ist, und Aroyl Benzoyl, substituiertes Benzoyl oder Naphthoyl darstellt;

oder

X Wasserstoff darstellt und eine Doppelbindung zwischen der 3- und der 4-Position des 1,5-Anhydrohexitolrings angeordnet ist.

9. Pharmazeutische Zusammensetzung nach Anspruch 8, gekennzeichnet durch antivirale Aktivität gegen herpesartige Viren, ausgewählt aus der Gruppe, bestehend aus Herpes Simplex Virus Typ I (HSV-1), Herpes Simplex Virus Typ 2 (HSV-2), Varicella Zoster Virus (VZV) und Cytomegalo Virus (CMV), wie auch gegen Pockenviren, wie

zum Beispiel Vaccinia Virus (VV).

10. Pharmazeutische Zusammensetzung nach Anspruch 8, dadurch gekennzeichnet, daß sie den aktiven Bestandteil in einer Konzentration zwischen ungefähr 0,1 und 100 Gewichts-% enthält.

11. Pharmazeutische Zusammensetzung nach Anspruch 9, dadurch gekennzeichnet, daß die Zusammensetzung in der Form ausgewählt aus der Gruppe, bestehend aus Pulvern, Suspensionen, Lösungen, Sprays, Emulsionen, Salben und Cremes vorliegt.

12. Verwendung der 1,5-Anhydrohexitol-Nukleosidanalogen der Formel I nach einem der Ansprüche 1-6 als Mittel mit biologischer Aktivität.

13. Verwendung der 1,5-Anhydrohexitol-Nukleosidanalogen der Formel I nach einem der Ansprüche 1-6 als Mittel mit antiviraler Aktivität gegen Herpesviren, Pockenviren und verwandte Viren.

14. Verwendung von 1,5-Anhydrohexitol-Nukleosidanalogen der Formel I nach Anspruch 1 zur Herstellung einer pharmazeutischen Zusammensetzung mit antiviraler Aktivität gegen Herpesviren, Pockenviren und verwandte Viren.

15. Verwendung eines 1,5-Anhydrohexitol-Nukleosidanalogon der Formel I nach Anspruch 1, worin:

B ein heterocyclischer Ring ist, der aus der Gruppe stammt, bestehend aus Pyrimidin- und Purinbasen, und
X Wasserstoff, Azido, F, Cl, Br, I, Amino, $-NHR^2$, $-N(R^2)_2$, $-OR^2$, $-SR^2$ oder CN darstellt;
wobei R^1 und R^2 gleich oder verschieden sind und Wasserstoff, Alkyl-, Acyl- oder Phosphatbestandteile darstellen; wobei:

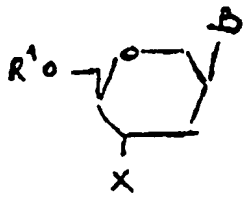
- Alkyl ein gesättigter oder ungesättigter, substituierter oder unsubstituierter Kohlenwasserstoffrest mit 1-20 Kohlenstoffatomen und gerad- oder verzweigtkettig ist, und
- Acyl ein Alkanoyl- oder Aroylbestandteil ist, in dem Alkanoyl ein Alkylcarbonylrest ist, worin Alkyl wie oben beschrieben ist, und Aroyl Benzoyl, substituiertes Benzoyl oder Naphthoyl darstellt;

oder
X Wasserstoff darstellt und eine Doppelbindung zwischen der 3- und der 4-Position des 1,5-Anhydrohexitolrings angeordnet ist, oder ein pharmazeutisch akzeptables Salz oder Ester hiervon

in einem Verfahren zur Behandlung von Viruserkrankungen, verursacht durch Herpesviren, Pockenviren und verwandte Viren.

Revendications

1. Analogues de nucléosides 1,5-anhydrohexitols représentés par la formule générale I :



(I)

dans laquelle :

B est un noyau hétérocyclique qui dérive du groupe constitué des bases pyrimidiques et puriques, et
X représente un atome d'hydrogène, un groupe azido, F, Cl, Br, I, un groupe amino, $-NHR^2$, $-N(R^2)_2$, $-OR^2$, $-SR^2$ ou CN;
où R^1 et R^2 sont identiques ou différents et les fragments hydrogène, alkyle, acyle ou phosphate sont représentés; où :

- l'alkyle est un radical hydrocarboné, saturé ou non saturé, substitué ou non substitué, possédant de 1 à 20 atomes de carbone et une chaîne linéaire ou ramifiée, et
- l'acyle est un fragment alcoyle ou aroyle, dans lequel l'alcoyle est un radical alkylcarbonyle, l'alkyle étant tel que décrit ci-dessus, et l'aroyle représente un groupe benzoyle, benzoyle substitué ou naphtoyle;

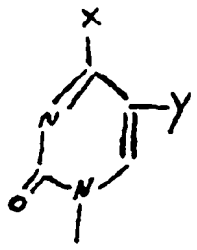
ou

X représente un atome d'hydrogène et une double liaison est située entre la position 3- et la position 4- du cycle 1,5-anhydrohexitol, en sus de leurs sels et esters pharmaceutiques.

2. Analogues de nucléosides 1,5-anhydrohexitols selon la revendication 1, caractérisés en ce que l'hexitol a la configuration D-, et en ce que le fragment de type base et le substituant X ont tous les deux la configuration (S)-.

3. Analogues de nucléosides 1,5-anhydrohexitols selon la revendication 1, caractérisés en ce que X représente un groupe hydroxyle dans la configuration (S)-.

4. Analogues de nucléosides 1,5-anhydrohexitols selon la revendication 1, caractérisés en ce que le noyau hétérocyclique qui dérive du groupe constitué des bases pyrimidique et puriques est représenté par la formule III:



(III)

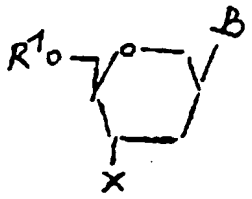
dans laquelle :

X représente OH, NH_2, NHQ,
où :
Q représente OH ou un groupe alkyle en C_{1-5};
Y représente H, F, Cl, Br, un groupe alkyle en C_{1-5}, un groupe halogénoéthyle ou CH=CH-R, où R représente un atome d'hydrogène, un atome d'halogène ou groupe alkyle en C_{1-5}, et où le groupe halogénoéthyle contient de 1 à 4 atomes de F, de Cl, ou de Br.

5. Analogues de nucléosides 1,5-anhydrohexitols selon la revendication 1, caractérisés en ce que le noyau hétérocyclique qui dérive du groupe constitué des bases pyrimidiques et puriques est choisi dans l'ensemble constitué d'adénine, guanine, hypoxanthine et xanthine, substituées et non substituées, éventuellement substituées par un atome d'halogène, un groupe alkyle en C_{1-5} ou - CH=CH-R, où R représente un atome d'hydrogène, un atome d'halogène ou un groupe alkyle en C_{1-5}.

6. Analogues de nucléosides 1,5-anhydrohexitols selon la revendication 1, caractérisés en ce que des analogues aza-, désaza-, désoxy- ou désamino- de chacun des noyaux hétérocycliques, qui si cela est souhaité portent un ou plusieurs substituants tels que définis dans l'une quelconque des revendications précédentes, sont présents dans les composés de formule I.

7. Procédé de préparation d'analogues 1,5-anhydrohexitols représentés par la formule générale I



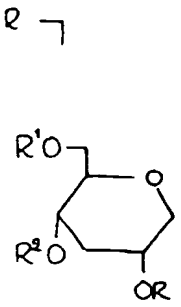
dans laquelle :

B est un noyau hétérocyclique qui dérive du groupe constitué des bases pyrimidiques et puriques, et
X représente un atome d'hydrogène, un groupe azido, F, Cl, Br, I, un groupe amino, $-NHR^2$, $-N(R^2)_2$, $-OR^2$, $-SR^2$ ou CN;
où R^1 et R^2 sont identiques ou différents et les fragments hydrogène, alkyle, acyle ou phosphate sont représentés; où :

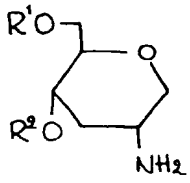
- l'alkyle est un radical hydrocarboné, saturé ou non saturé, substitué ou non substitué, possédant de 1 à 20 atomes de carbone et une chaîne linéaire ou ramifiée, et
- l'acyle est un fragment alcoyle ou aroyle, dans lequel l'alcoyle est un radical alkylcarbonyle, l'alkyle étant tel que décrit ci-dessus, et l'aroyle représente un groupe benzoyle, benzoyle substitué ou naphtoyle;

en plus des sels et esters pharmaceutiques de ceux-ci, ledit procédé comportant les étapes consistant à :

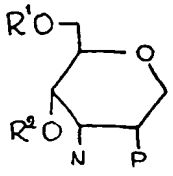
a) d'abord, fabriquer des dérivés de 1,5-anhydrohexitol convenablement protégés, représentés par les formules générales X, XI, et XIII



X



XI



XIII

dans lesquelles R^1 et R^2 représentent des groupes protecteurs (par exemple R^1, R^2 = C_6H_5-CH=) et R représente une fonction labile (par exemple R=SO_2CH_3, $SO_2C_6H_4CH_3$, $SO_2C_6H_4Br$) ou R = H;
b) fournir la base purique ou pyrimidique

i. en couplant une base purique ou pyrimidique,
soit :

- à des composés de formule X par substitution nucléophile du groupe labile en position 2; soit :
- par hydrolyse du groupe protecteur temporaire R, grâce à quoi le composé de formule X est obtenu, dans lequel R = H, puis par alcalinisation de la base purique ou pyrimidique;

ii. en construisant une base hétérocyclique à l'aide de protocoles classiques après avoir introduit une fonction amine dans la configuration (S) (formule XI); ou
iii. en utilisant le dérivé XIII, dans lequel P représente -OR et N est un groupe hydroxyle, et où R représente

une fonction labile telle qu'indiquée ci-dessus, ou
P et N sont des composants d'une époxydation pour introduire le noyau hétérocyclique en position 2-, suivie de l'élimination du groupe hydroxyle en position 3-;

c) si nécessaire, transformer le composé obtenu en sels ou esters pharmaceutiquement acceptables de celui-ci.

8. Composition pharmaceutique possédant une activité antivirale contre les herpèsvirus, les poxvirus et les virus apparentés, ladite composition comprenant comme ingrédient actif un analogue de nucléoside 1,5-anhydrohexitol de formule I, dans laquelle :

B est un noyau hétérocyclique qui dérive du groupe constitué des bases pyrimidiques et puriques, et
X représente un atome d'hydrogène, un groupe azido, F, Cl, Br, I, un groupe amino, $-NHR^2$, $-N(R^2)_2$, $-OR^2$, $-SR^2$ ou CN;
où R^1 et R^2 sont identiques ou différents et les fragments hydrogène, alkyle, acyle ou phosphate sont représentés; où :

- l'alkyle est un radical hydrocarboné, saturé ou non saturé, substitué ou non substitué, possédant de 1 à 20 atomes de carbone et une chaîne linéaire ou ramifiée, et
- l'acyle est un fragment alcoyle ou aroyle, dans lequel l'alcoyle est un radical alkylcarbonyle, l'alkyle étant tel que décrit ci-dessus, et l'aroyle représente un groupe benzoyle, benzoyle substitué ou naphtoyle;

ou
X représente un atome d'hydrogène et une double liaison est située entre la position 3- et la position 4- du cycle 1,5-anhydrohexitol.

9. Composition pharmaceutique selon la revendication 8, caractérisée par une activité antivirale contre les virus ressemblant à celui de l'herpès, qui sont choisis dans le groupe constitué du virus herpès simplex de type 1 (HSV-1), du virus herpès simplex de type 2 (HSV-2), du virus varicelle-zona (VZV) et du cytomégalovirus (CMV), ainsi que contre les poxvirus, par exemple le virus de la vaccine (VV).

10. Composition pharmaceutique selon la revendication 8, caractérisée en ce que la composition contient l'ingrédient actif à une concentration comprise entre environ 0,1 et 100% en poids.

11. Composition pharmaceutique selon la revendication 9, caractérisée en ce que la composition prend la forme choisie dans le groupe constitué des poudres, des suspensions, des solutions, des pulvérisations, des émulsions, des baumes et des crèmes.

12. Analogues de nucléosides 1,5-anhydrohexitols de formule I tels que définis dans les revendications 1 à 6, destinés à être utilisés comme agent possédant une activité biologique.

13. Analogues de nucléosides 1,5-anhydrohexitols de formule I tels que définis dans les revendications 1 à 6, destinés à être utilisés comme agent possédant une activité antivirale contre les herpèsvirus, les poxvirus et les virus apparentés.

14. Utilisation d'analogues de nucléosides 1,5-anhydrohexitols de formule I tels que définis dans la revendication 1 pour la préparation d'une composition pharmaceutique possédant une activité antivirale contre les herpèsvirus, les poxvirus et les virus apparentés.

15. Analogue de nucléoside 1,5-anhydrohexitol de formule I, tel que défini dans la revendication 1, dans lequel

B est un noyau hétérocyclique qui dérive du groupe constitué des bases pyrimidiques et puriques, et
X représente un atome d'hydrogène, un groupe azido, F, Cl, Br, I, un groupe amino, $-NHR^2$, $-N(R^2)_2$, $-OR^2$, $-SR^2$ ou CN;
où R^1 et R^2 sont identiques ou différents et les fragments hydrogène, alkyle, acyle ou phosphate sont représentés; où :

- l'alkyle est un radical hydrocarboné, saturé ou non saturé, substitué ou non substitué, possédant de 1 à

20 atomes de carbone et une chaîne linéaire ou ramifiée, et

- l'acyle est un fragment alcoyle ou aroyle, dans lequel l'alcoyle est un radical alkylcarbonyle, l'alkyle étant tel que décrit ci-dessus, et l'aroyle représente un groupe benzoyle, benzoyle substitué ou naphtoyle;

ou

X représente un atome d'hydrogène et une double liaison est située entre la position 3- et la position 4- du cycle 1,5-anhydrohexitol, ou un sel ou ester pharmaceutiquement acceptable de celui-ci

destiné à être utilisé dans une méthode de traitement des affections virales causées par les herpèsvirus, les poxvirus et les virus apparentés.